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Blood Composition of Normal Beef Cattle

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CONTENTS

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The level of certain constituents in the blood of animals has been shown to be useful in the evaluation of nutritional status both under controlled conditions of feeding and during normal management. Methods for the determination of various constituents have been developed to the point where they constitute useful tools for evaluating changes in the physiological condition of the animal in response to variation in feeding or management. Such evaluation by chemical means frequently permits more accurate determination of the response of the animal and thus reduces the number of experimental animals necessary to obtain a sufficient amount of data to reach a reliable conclusion.

A group of studies on the nutrition of beef cattle constitutes one of the more important phases of investigation currently under way at the Oklahoma Agricultural Experiment Station. In connection with these various studies, it was deemed desirable to examine the blood, organs, and tissues of experimental animals to supplement other findings as to the response of animals to variations in nutrition and management. An examination of the literature showed that although a considerable amount of work has been done on the normal levels of various constituents in bovine blood, the bulk of this information concerned cattle of dairy breeding during periods of intensive lactation.

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The scattered information that has been reported concerning beef cattle has dealt largely with the Hereford breed. Marked differences in certain constituents have been observed in various breeds of dairy cattle. These findings suggested that similar differences might exist among various breeds of beef cattle.

In order, therefore, to accurately interpret data obtained on experimental animals, it was thought desirable to determine the levels of various constituents of blood obtained from cattle of the three principal breeds of beef cattle under conditions of nutrition and management commonly found in Oklahoma. Variation in the level of these constituents could then be correlated with such factors as age, season, reproduction and lacation, and other variations in feeding and management. This report deals with the blood levels of carotene, vitamin A, ascorbic acid, calcium, phosphorus, and hemoglobin, and the red blood cell count of three breeds of beef cattle: Hereford, Shorthorn, and Angus.

EXPERIMENTAL

The subjects studied in this investigation were ten mature cows and five heifers. The heifers were under one year of age at the beginning of the experimental period. Representative animals of each of the three principal beef breeds (Angus, Hereford, and Shorthorn) were selected from the pure-bred herd of the Oklahoma A. & M. College. The animals of a particular breed were of closely related lines of breeding and many of them had a considerable number of common ancestors. A few animals had to be removed from the experimental group for various reasons during the period of study; when this was necessary they were replaced by animals of comparable breeding, age and stage of reproduction.

Under the system of management employed by the Oklahoma A. & M. College, most of the cows were grazed on the Beef Cattle Experimental Range, 13 miles west of Stillwater, until they had calved and were ready to be rebred. At the time of breeding the animals were brought to small pastures located adjacent to the beef cattle barns on the College campus, where they remained until they were known to be safely with calf. This meant that a certain amount of ration variability was obtained at the two locations, but the great majority of the animals were present at the Range during the two years under investigation.

Feeding practice at the Range during the summer season: (essentially mid-April to late October) consisted of allowing the animals to graze native grass pastures. Pastures at the Range consist of native grasses

in which the prominent species are big bluestem, little bluestem, Indian, and switch grasses.

During the winter period at the Range the animals were allowed access to approximately ten acres of native range, and in addition were fed 2½ pounds of cottonseed cake or soybean meal per day. Limited amounts of Atlas sorgo silage and prairie hay were fed during periods of severe winter weather.

While at the barn in Stillwater during the winter, the animals, in addition to having access to a limited amount of Bermuda grass pasture, received 2 pounds of cottonseed cake, 1½ pounds of rolled oats and 1½ pounds wheat bran per day as a concentrate mixture. The roughage consisted of 20 pounds of Atlas sorgo silage and 5 pounds of alfalfa hay.

At the barn during the summer the cows had access to Bermuda grass pasture and were fed approximately 2 pounds of oats and 2 pounds of bran per head daily and as much Atlas sorgo silage as they would consume.

At all times, both at the Range and at the barn, all animals had access to a mineral mixture composed of equal parts of salt, bonemeal and ground limestone.

The animals were bled at essentially monthly intervals beginning in August, 1947, and continuing for two years. Blood was collected by venous puncture into citrated tubes and promptly delivered to the laboratory. All determinations except red blood cell count and hemoglobin were made on the plasma. The following methods were used for the various chemical determinations: carotene and vitamin A essentially as described by Kimble (2); ascorbic acid by the photometric determination of the reduction of 2, 6 dichlorophenol indophenol, a modification of the method of Mindlin and Butler (4); calcium by the method of Clark and Collip (1); inorganic phosphorus as the trichloroacetic-acid-soluble phosphorus determined by the method of Youngburg and Youngburg (9). Red blood cell count was measured indirectly by the following procedure: 0.02 ml. of whole blood was added to 10 ml. of normal saline and the turbidity determined using the Evelyn colorimeter at 720 millimicrons. The values so obtained were correlated with determinations made by direct counting procedures and a relationship established between the turbidity and the red cell count. Hemoglobin was determined by the acid hematin procedure, the density of the color being read in an Evelyn photometric colorimeter. The readings were standardized by determining hemoglobin on a series of samples by the method of Wong (8).

Complete records were maintained on the animals during their entire experimental period in an attempt to evaluate more closely the

results obtained. Unfortunately, limitations of space do not permit the presentation of individual data. This has been summarized by Long (3) for the first year of the study.

RESULTS AND DISCUSSION

The experimental data relating blood composition to season are presented in Tables I through VII (pages 17 to 23) and graphically in Figures 1, 2 and 3. After careful examination of the data it was believed justifiable to group those animals at the Range and those on more restricted pasture together. Although differences in ration were present, particularly during the summer season, these differences did not appear to be sufficiently great to justify separate treatment.

Carotene.

Examination of the carotene values of cows (Table I) shows that there was no striking differences in blood composition among the three breeds. In general, it will be noted that the Shorthorn breed had a higher plasma carotene than did either Hereford or Angus. Throughout the entire period the Shorthorn group of cows had, without exception, a higher blood plasma carotene than did Hereford and higher with only three exceptions than Angus. In most instances the differences among breeds were not great enough to reveal statistical significance. In view of the limited numbers of animals involved, it may be that a quantitative difference in ability to convert carotene to vitamin A exists between Shorthorn and the other two breeds. Such a difference has been observed among the breeds of dairy cattle.

The expected seasonal variation in carotene content was observed. During the two years, the maximum value was reached during early spring, fell gradually throughout the summer months and then declined more precipitously through the early winter, reaching a minimum in both years in February. During the first year of the study, values below 100 were observed in both the Hereford and Angus breeds for the two consecutive months of January and February. In the subsequent year, the decline was less marked. This is attributed to the fact that the winter of 1949 was considerably less severe than was the winter of 1948, and unquestionably animals had access to a larger quantity of winter grasses and forbs during the second year than was the case during the first.

Age had no apparent effect upon the levels of carotene in the blood of any of the cows. Examination of the raw data shows that there was a much more constant pattern with respect to individuals than there

was with respect to age among animals, even within a single breed. In general, it was observed that animals higher in carotene in one period than the average remained higher at subsequent periods, suggesting that individual ability to absorb carotene may be relatively more important than other factors. The observations made in dairy breeds by Sutton and others (5, 6) that the carotene content of the plasma declines subsequent to parturition was observed in these studies with all three of the beef breeds. This suggests the importance of such a physiological stress as lactation on the concentration of this constituent in the blood and should be taken into consideration in evaluating the results of blood analysis in lactating cows.

In the case of heifers (Figure 1), the pattern observed with respect to this nutrient was very similar to that found with older cows. The maximum value for carotene was noted in early summer in both heifers and cows in both years, and the rates of decline throughout the season were parallel. During the second year, the general tendency for the Shorthorn breed to exceed the others with respect to carotene content can be noted; during the first year there were no consistent differences among the three breeds.

Vitamin A.

The general seasonal trend in vitamin A concentration of plasma was similar to that for carotene (Table II); i. e., the highest values observed throughout the period were noted in mid-summer, followed by a general decline throughout the winter period with a low value being reached in March and April. In only one month throughout the entire period was the plasma vitamin A level below that considered necessary for good nutrition. This occurred at a period in which there had been a sharp increase in plasma carotene. It has been observed in other work at this Station and by workers elsewhere that high carotene values are sometimes associated with abnormally low plasma vitamin A as determined by the development of the blue color with the Carr-Price reagent. Whether this apparent decrease is due to techniques employed, which necessitate making a very high correction value for the blue color produced by carotene, or whether it really represents a tendency for high plasma carotene to force vitamin A from the blood stream into the storage organs is not known.

A comparison of breeds again suggests that the Shorthorn may be slightly more efficient in its ability to absorb carotene and convert it to vitamin A. In contrast to the carotene results, however, in many instances the plasma vitamin A of Shorthorns was less than that of either the Angus or Herefords. The variation within a single breed

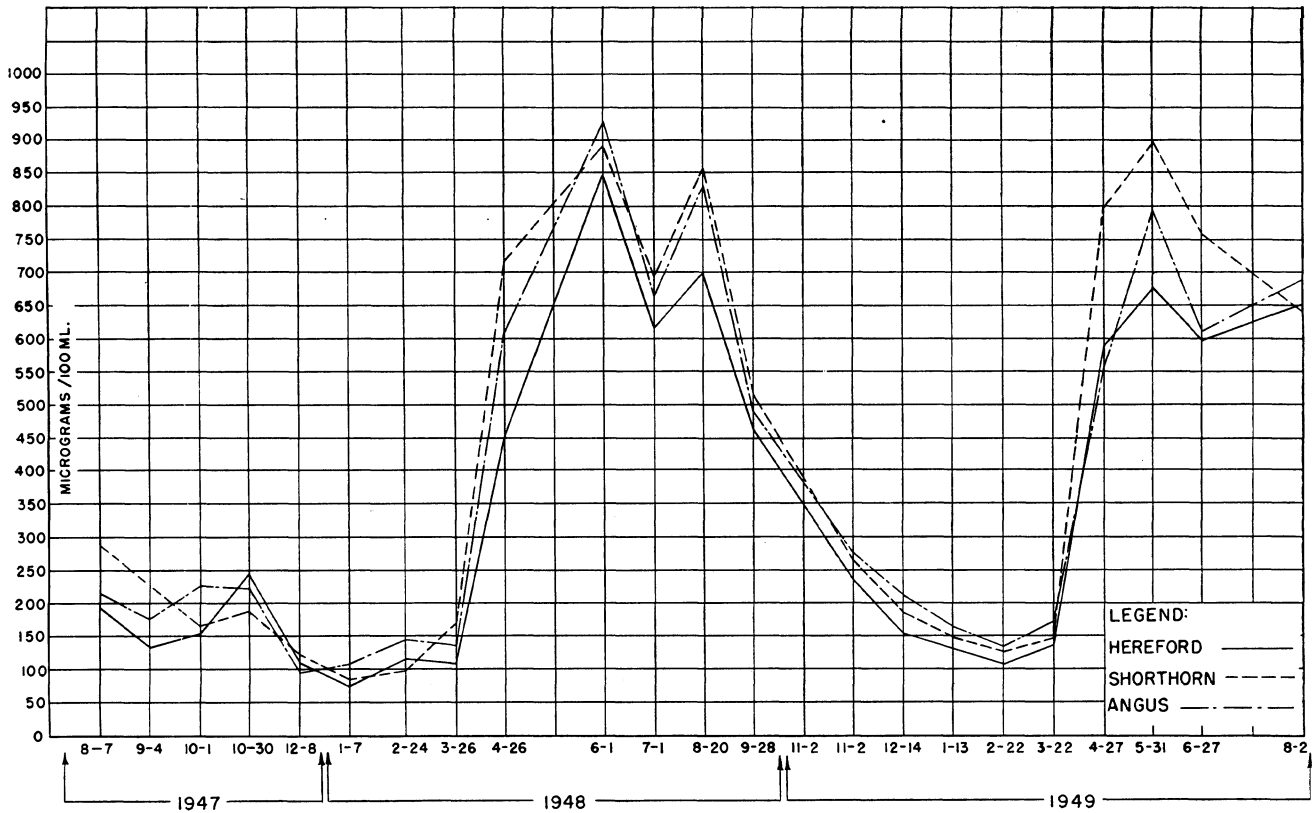

Figure 1.—Carotene Content of Heifer Plasma.

was so large that an extremely large number of animals would have to be examined in order to show whether or not there was any difference among the various breeds with respect to the levels of this constituent. From a practical point of view, it seems likely that average values determined with any system of management for one breed could be used without modification in interpreting the blood values observed in another.

Examination of Figure 2 shows that heifers did not differ materially from the older cows in vitamin A content of plasma. The correlation with carotene concentration was high, shifts tending to follow rather than occur simultaneously with variations in carotene concentration. During only one month throughout the entire period did the vitamin A content fall below 20 micrograms per 100 mls., which is frequently considered the lower limit of the optional range of concentration. In common with the older cows, heifers of Shorthorn breeding frequently had a higher vitamin A blood level.

Ascorbic Acid.

Since beef cattle are capable of synthesizing ascorbic acid within their own tissues, only a limited number of observations were made in order to establish normal ranges. It has been suggested that low plasma ascorbic acid may be found in bulls of low fertility, and it was deemed desirable to establish normal levels for beef cows. Considerable variation was observed from time to time, but this variation appeared to be unrelated to season or any other obvious environmental factor. The mass of values fell between 150 and 300 mg. of ascorbic acid per 100 cc. of plasma, and it is suggested that this represents the average normal range of values for beef cattle under this system of management. From a technical point of view, it should be recognized that the determination of ascorbic acid for blood plasma is probably the least satisfactory of any determination attempted in this study. We present these data with reservations, therefore, and suggest that normal means be determined under the particular conditions encountered by other workers who have occasion to examine the blood of beef cattle for this constituent.

Calcium.

The nature of the management used for the animals in this study was such as to provide ample amounts of calcium at all times. A sufficient number of samples were included to assure that there were no differences among the three breeds under investigation, and the study was terminated at the end of a single year of collection. Plasma calcium

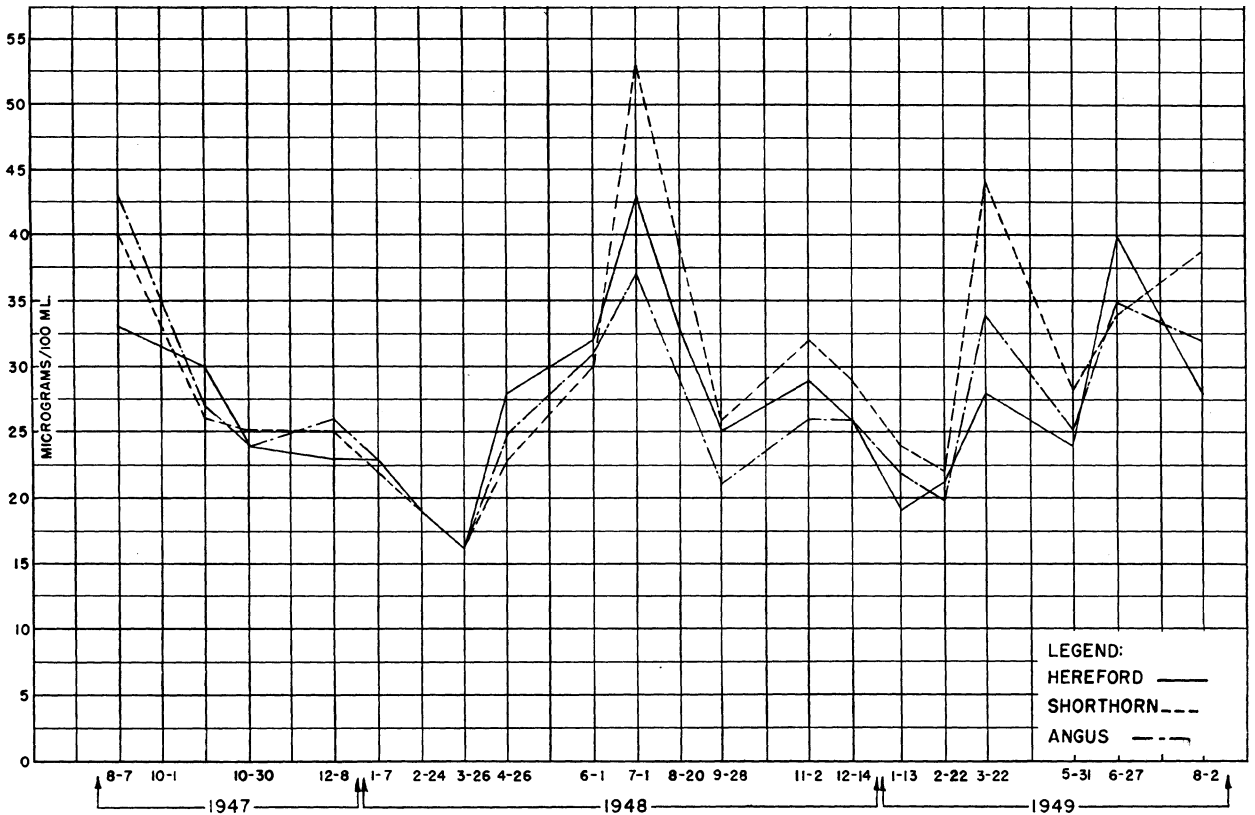

Figure 2.—Vitamin "A" Content of Heifer Plasma.

values fluctuated between relatively narrow limits, a minimum of 10.1 and a maximum of 12.2 being observed. There appeared to be no seasonal variation with regard to calcium content. It may be that variation in the calcium content of the blood might have been observed if the animals had not been allowed access to a mineral supplement. The large reserve of calcium in the bone, however, makes it doubtful that this constituent would show much change until a severe deficiency had been precipitated.

Phosphorus.

Examination of the data on inorganic phosphorus content of the plasma of the three breeds shows no consistent breed difference with respect to this constituent. The animals were all on a relatively high plane of nutrition with respect to this nutrient, and this may account for the fairly narrow range within which this constituent varied. In only five instances during the entire period did the average value fall below 4.0 mg. of phosphorus per 100 ml. of plasma. There were numerous instances of individual cows in all breeds which had values constantly lower than 4.0 mg. percent without any apparent ill effects on reproductive capacity. Maximum values observed were slightly above 6.0 mg. percent, and usually occurred during a period in which cottonseed meal was being fed as a protein supplement. Because of this management practice the highest level of inorganic phosphorus was noted during the early winter and the lowest during the late fall just before the animals began to receive this protein supplement. These figures tend to confirm the generally held belief that animals on a high plane of phosphorus nutrition will maintain a blood level of not less than 4.0 mg. percent. A considerable mass of data collected at this Station and by New Mexico workers (7) suggests, however, that normal reproductive performance can be obtained in beef cattle having blood plasma phosphorus levels considerably below 4.0. It is suggested, therefore, that workers attempting to use inorganic phosphorus as a measure of the phosphorus nutrition of beef cattle exercise considerable caution in the interpretation of blood composition values.

Examination of the data presented in Figure 3 also indicates another reason for caution in the interpretation of phosphorus values. It will be seen that the seasonal variation in phosphorus content, which was apparent in older animals due to the feeding of concentrates containing large amounts of phosphorus, was obscured by the gradual downward trend in blood phosphorus as the animals matured. A reasonably consistent decline was found from the high values near 7.5 mg. percent at the beginning of the study when the heifers averaged less than six

months of age to about 4.5 percent during the summer months two years later. Such a consistent downward trend would obviously tend to make increases due to dietary changes or other causes less obvious than would otherwise be the case.

Red Blood Cell Count.

Examination of the data for red cell count in these animals again fails to indicate any consistent breed difference. All breeds had a normal variation from about 4½ to 6 million red blood cells per cubic milimeter. Whether this variation represents a true shift in red cell count is highly questionable. Rather it is thought that a major portion of the variability is due either to the state of the animal at the time that the blood sample was collected or to the fact that the method of determining red cell count by indirect turbidity techniques did not have as high a degree of precision as might be desired. However, these data do suggest that, using this procedure, cattle being handled under an excellent system of management, have apparent red blood cell values near 4.0 without any signs of true clinical anemia as indicated by hemoglobin content.

Hemoglobin.

As would be expected from a failure to observe differences in red cell count, no differences with respect to hemoglobin were observed.

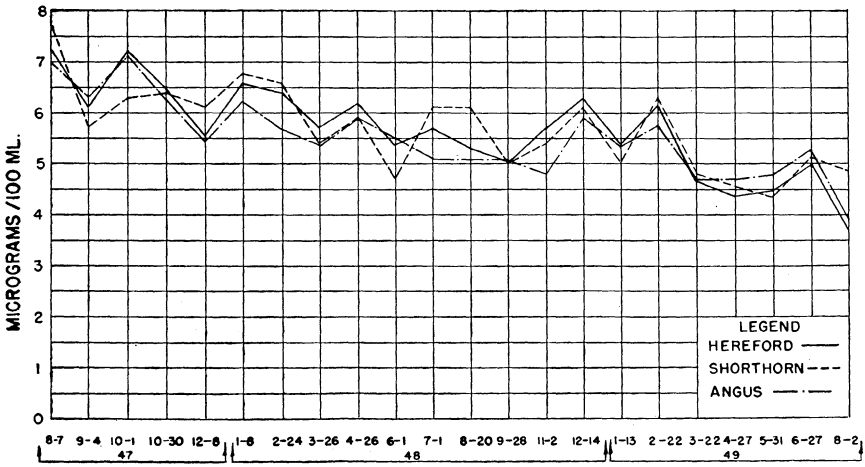

Figure 3.—Phosphorus Content of Heifer Plasma.

Minimal values found during the entire period were slightly above 8.0, with maximum values being slightly more than 13.0. This represents a wide range for a constituent presumably as stable in concentration as hemoglobin. Most of the low hemoglobin values correlated excellently with low red cell count, however, and it seems likely the values observed represent real differences rather than being due to a procedural error of some type. It may be that the physiological state of the animal at the time the samples were collected affected the total circulating blood volume or that some other physiological response produced a variation in the red cell count and hemoglobin concentration unrelated to nutrition. In any event, it again appears that workers examining blood of cattle for hemoglobin should be most cautious in suggesting that individual values near 8.0 represent a true anemic state. There was nothing in the feeding nor responses of the animals to suggest any possibility of anemia. A similar variation from individual to individual, and from time to time in the same individual, has been noted in human beings. Variations less than 20 percent from the physiologically normal values are not infrequently considered of little clinical significance. The total number of red cells in beef cattle are essentially the same as many other species, including human beings, while the total amount of hemoglobin found in this study was considerably less.

SUMMARY

The blood composition of the three principal breeds of beef cattle has been studied under favorable conditions of feeding and management to provide basic information which would be useful in the interpretation of data obtained from animals undergoing various experimental treatments or in the diagnosis of nutritional disease. The following components were determined in Hereford, Angus and Shorthorn cows and heifers through two successive years: carotene, vitamin A, ascorbic acid, calcium, phosphorus, erythrocyte count, and hemoglobin.

Plasma carotene was significantly affected by season, but was not greatly different in cows and heifers and was similar in all breeds. Observed values varied from an average low of 71 to a high of 1027 micrograms/100 ml. A general tendency for the Shorthorn breed to have a higher carotene level was noted; differences, however, were not sufficiently large to be statistically significant due to variability within a breed. The same general pattern was observed with respect to plasma vitamin A, except that the Shorthorn breed tended to be slightly higher than the other two, thus supporting the view that the breed may be slightly more efficient in absorbing carotene and converting it to vitamin A. The constituent fluctuated from 9.3 to 47.4 micograms per 100 ml. of plasma.

Plasma ascorbic acid values fell generally between 150 and 300 mg. percent and were unrelated to any obvious dietary, environmental, age, or breed differences.

Plasma calcium varied within relatively narrow limits (10.0 to 12.2 mg. percent) and was not obviously correlated with season, breed or age.

Inorganic phosphorus of plasma showed no obvious relation to breed differences but was affected by dietary and seasonal factors and by age. Animals receiving cottonseed cake or meal as a protein supplement showed marked increases in plasma inorganic phosphorus during the winter months despite the lower phosphorus content of the roughage. A constituent decline in inorganic phosphorus was noted in the heifers from a high of 7.5 at approximately six months of age to 4.5 mg. percent during the summer months two years later. Numerous instances were noted in which the phosphorus level in mature animals was consistently less than 4.0 mg. percent without any signs of inadequate phosphorus nutrition.

Erythrocyte count and hemoglobin were apparently unrelated to breed, season or age. Mean values for all breeds were as follows: erythrocyte count, 5.35±0.55 cells per cubic millimeter; hemoglobin, 10.7±1.08 percent.

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CAROTENE CONTENT

Table I.—Carotene Content of Beef Cattle Plasma.

(Micrograms per 100 ml.)

Date of Sampling	Average Composition of Plasma			Variance								
				Hereford			Shorthorn			Angus		
	Hereford	Shorthorn	Angus	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error
8- 7-47	430.4	505.0	527.1	10	144.1	45.6	9	218.7	72.9	10	242.1	76.6
9- 4-47	332.7	402.5	339.4	10	71.8	22.7	10	231.0	73.0	10	133.9	42.4
10- 1-47	333.5	415.6	330.0	10	66.2	20.9	10	155.3	49.1	9	73.8	24.6
10-30-47	274.9	364.4	299.0	10	67.0	21.2	8	115.0	40.7	9	42.5	14.2
12- 8-47	124.1	173.0	124.2	9	27.5	9.2	8	71.7	25.3	9	36.0	12.0
1- 7-48	93.7	106.9	90.1	10	30.4	9.6	10	40.6	12.8	10	23.7	7.5
2-24-48	71.1	105.9	72.0	10	48.5	15.3	10	65.6	20.7	10	34.8	11.0
3-26-48	128.2	173.1	128.5	10	38.6	12.2	10	64.8	20.5	10	23.8	7.5
4-26-48	557.2	730.1	740.5	9	229.7	76.6	10	189.9	60.1	10	288.4	91.2
6- 1-48	794.9	1027.1	883.5	10	404.7	128.0	10	350.2	110.7	10	235.5	74.5
7- 1-48	712.4	938.7	647.0	9	333.5	111.2	10	439.5	139.0	9	183.9	61.3
8-20-48	752.6	880.2	837.1	10	209.4	66.2	10	352.8	111.6	10	319.7	101.1
9-28-48	491.3	554.1	501.6	10	95.2	30.1	9	174.7	58.2	10	195.1	61.7
11- 2-48	260.8	283.2	252.6	10	53.8	17.0	10	123.6	39.1	10	109.2	34.5
12-14-48	153.9	203.9	214.5	10	30.1	9.5	9	96.6	32.2	10	82.7	26.2
1-13-49	126.0	161.4	159.6	10	23.4	7.4	10	52.9	13.6	10	36.9	11.7
2-22-49	96.9	129.7	121.8	10	14.4	4.5	10	31.8	10.1	9	32.0	10.7
3-22-49	130.6	158.1	147.6	10	23.7	7.5	9	30.9	10.3	10	52.9	16.7
4-27-49	511.4	895.4	628.1	10	241.7	76.4	9	299.6	99.9	10	307.9	97.4
5-31-49	647.1	950.7	754.8	10	300.7	95.1	10	259.4	82.0	10	204.5	64.7
6-27-49	613.6	815.5	624.3	10	299.9	94.8	10	355.8	112.5	10	177.2	56.0
8- 2-49	455.9	730.9	640.3	7	145.9	55.2	10	258.5	81.7	8	164.8	58.3

VITAMIN A CONTENT

Table II.—Vitamin A Content of Beef Cattle Plasma.

(Micrograms per 100 ml.)

Date of Sampling	Average Composition of Plasma			Variance								
				Hereford			Shorthorn			Angus		
	Hereford	Shorthorn	Angus	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error
8- 7-47	36.5	45.3	47.4	10	10.5	3.3	9	15.8	5.3	10	24.4	7.7
10- 1-47	24.0	29.7	21.5	10	5.8	1.8	10	7.0	2.2	9	4.8	1.6
10-30-47	21.9	26.8	20.0	10	5.5	1.7	8	4.7	1.7	9	4.0	1.3
12- 8-47	26.4	23.3	19.7	9	4.4	1.5	8	3.1	1.1	9	2.9	1.0
1- 7-48	25.4	27.7	20.5	10	5.4	1.7	10	6.2	2.0	10	3.5	1.1
2-24-48	20.1	22.7	14.4	10	6.5	2.1	10	6.8	2.2	10	4.7	1.5
3-26-48	14.8	16.8	12.1	10	4.8	1.5	9	3.7	1.2	10	4.1	1.3
4-26-48	22.4	18.8	14.1	9	6.8	2.3	10	9.9	3.1	8	6.8	2.4
6- 1-48	25.7	22.6	20.9	10	12.6	4.0	10	10.4	3.3	10	6.1	1.9
7- 1-48	41.4	35.3	29.9	9	10.4	3.5	10	15.8	5.0	9	8.3	2.8
8-20-48	32.4	38.7	28.8	10	8.0	2.5	10	6.6	2.1	10	6.1	1.9
9-28-48	22.1	28.7	19.2	10	6.5	2.1	8	7.4	2.6	10	7.9	2.5
11- 2-48	29.2	31.0	26.0	10	6.4	2.0	10	4.9	1.6	10	5.7	1.8
12-14-48	25.8	28.0	22.4	10	4.2	1.3	9	6.4	2.1	10	4.6	1.5
1-13-49	18.7	22.3	20.3	10	5.7	1.8	10	6.2	2.0	10	5.1	1.6
2-22-49	21.7	20.3	19.0	10	3.6	1.2	10	8.4	2.7	9	6.2	2.1
3-22-49	26.6	43.4	32.8	10	8.7	2.8	9	7.2	2.4	10	8.2	2.6
4-27-49	9.3	11.2	21.8	8	7.7	2.7	6	7.0	2.9	5	9.0	4.0
5-31-49	25.6	24.4	24.6	10	6.9	2.2	10	7.9	2.5	10	8.9	2.8
6-27-49	40.8	32.5	32.8	10	8.1	2.6	10	8.2	2.6	10	8.1	2.6
8- 2-49	34.7	28.9	27.8	7	11.6	4.4	10	6.5	2.1	8	4.2	1.5

VITAMIN C CONTENT

Table III.—Vitamin C Content of Beef Cattle Plasma.

(Micrograms per 100 ml.)

Date of Sampling	Average Composition of Plasma			Variance								
				Hereford			Shorthorn			Angus		
	Hereford	Shorthorn	Angus	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error
8- 7-47	115.1	153.8	121.4	9	63.9	21.3	8	129.8	45.9	10	57.5	18.2
9- 4-47	79.8	139.6	106.9	9	55.2	18.4	9	218.7	72.9	10	72.4	22.9
10- 1-47	144.1	161.9	127.7	10	65.7	20.8	10	80.4	25.4	9	57.0	19.0
10-30-47	306.5	278.7	259.2	10	95.2	30.1	7	66.1	25.0	9	45.8	15.3
12- 8-47	302.1	280.4	265.6	7	79.7	30.1	8	61.9	21.9	8	130.0	46.3
1- 7-48	285.2	270.0	250.3	9	89.2	29.7	10	71.8	22.7	10	93.1	29.4
2-24-48	193.7	204.0	173.4	6	95.1	38.8	5	49.4	22.1	7	67.9	25.7
3-26-48	375.4	321.4	335.2	10	56.9	18.9	10	76.2	24.1	10	83.3	26.3
4-26-48	449.6	379.3	366.9	9	83.9	28.0	9	82.3	27.4	9	158.9	53.0
6- 1-48	274.1	329.0	456.3	10	128.3	40.6	10	134.5	42.5	10	140.1	44.3
7- 1-48	376.8	289.6	263.4	10	209.5	66.3	10	63.4	20.0	9	102.5	34.2
8-20-48	177.0	189.4	194.4	10	109.6	34.7	8	130.4	46.1	10	86.0	27.2
9-28-48	221.3	191.7	194.7	10	52.4	16.6	10	59.4	18.8	10	53.8	17.0
11- 2-48	268.8	224.3	248.7	10	49.8	15.7	9	84.8	28.3	10	82.3	26.0

CALCIUM CONTENT

Table IV.—Calcium Content of Beef Cattle Plasma.

(Milligrams per 100 ml.)

Date of Sampling	Average Composition of Plasma			Variance								
				Hereford			Shorthorn			Angus		
	Hereford	Shorthorn	Angus	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error
8- 7-47	11.8	11.9	12.2	10	1.3	.41	9	.89	.30	10	1.3	.40
9- 4-47	10.8	10.5	10.4	10	.88	.28	10	1.2	.37	10	1.0	.32
10- 1-47	10.8	11.2	10.9	10	1.1	.33	10	.60	.19	9	.53	.18
10-30-47	10.9	10.9	11.1	10	.35	.11	8	.10	.04	8	.24	.08
12- 8-47	11.2	11.3	11.8	9	.25	.83	8	.30	.11	9	1.4	.45
1- 8-48	11.0	11.1	10.9	10	.09	.03	10	.10	.03	10	.26	.08
2-24-48	10.8	10.3	10.9	10	.51	.16	9	.57	.19	10	.62	.20
3-26-48	10.3	10.3	10.2	10	.67	.21	10	.94	.30	10	.43	.14
4-26-48	10.3	10.8	10.7	7	.59	.22	10	.40	.13	9	.49	.16
6- 1-48	11.1	11.3	11.5	10	.73	.23	9	.70	.23	10	.84	.27
7- 1-48	10.6	10.6	10.5	9	.91	.30	9	1.00	.33	8	1.1	.40
8-20-48	10.1	10.4	10.6	10	.79	.25	10	1.05	.33	10	1.3	.40

INORGANIC PHOSPHORUS CONTENT

Table V.—Inorganic Phosphorus Content of Beef Cattle Plasma.

(Milligrams per 100 ml.)

Date of Sampling	Average Composition of Plasma			Variance								
				Hereford			Shorthorn			Angus		
	Hereford	Shorthorn	Angus	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error
8- 7-47	5.1	5.0	5.8	10	1.30	.41	9	.79	.26	10	1.47	.47
9- 4-47	4.6	5.0	4.8	10	.39	.12	10	.77	.24	10	1.10	.35
10- 1-47	3.5	4.2	4.1	10	.69	.22	10	1.16	.37	9	1.13	.38
10-30-47	4.5	3.9	4.4	10	.89	.28	8	.93	.33	9	1.58	.53
12- 8-47	4.9	5.0	4.7	10	.62	.20	8	1.04	.37	9	.89	.30
1- 8-48	5.4	5.4	5.1	10	.56	.18	10	1.03	.33	10	.98	.31
2-24-48	5.3	5.3	5.1	10	.83	.26	10	.45	.14	10	1.09	.35
3-26-48	4.2	4.7	4.5	10	.78	.25	10	.83	.26	10	.75	.24
4-26-48	4.5	4.5	4.1	10	.96	.30	10	1.04	.33	10	.99	.31
6- 1-48	4.4	3.5	3.8	10	.76	.24	10	1.12	.35	10	1.24	.39
7- 1-48	4.8	5.1	4.9	10	.77	.24	10	.75	.24	9	1.39	.46
8-20-48	4.2	5.3	4.8	10	.94	.30	9	1.12	.37	9	1.00	.33
9-28-48	4.9	5.1	5.0	10	.34	.11	10	.39	.12	10	1.10	.35
11- 2-48	5.3	5.4	4.7	10	1.14	.36	10	.74	.23	10	1.05	.33
12-14-48	6.3	5.9	5.8	10	.64	.20	10	.85	.27	10	.97	.31
1-13-49	5.5	5.1	5.2	10	.66	.21	10	.73	.23	10	1.07	.34
2-22-49	6.2	6.1	5.6	10	1.00	.32	10	.90	.29	9	.95	.32
3-22-49	4.6	4.8	4.6	10	.55	.17	9	.40	.13	10	.63	.20
4-27-49	4.4	4.2	4.3	10	1.23	.39	9	.60	.20	10	.91	.29
5-31-49	4.3	4.2	4.5	10	1.15	.36	10	.91	.29	10	1.08	.34
6-27-49	4.9	4.7	5.3	10	.73	.23	10	1.23	.39	9	.53	.18
8- 2-49	3.9	4.3	4.1	7	.55	.21	10	.36	.11	8	.51	.18

HEMOGLOBIN CONTENT

Table VI.—Hemoglobin Content in Beef Cattle Blood.

(Grams per 100 ml.)

Date of Sampling	Average Composition of Plasma			Variance								
				Hereford			Shorthorn			Angus		
	Hereford	Shorthorn	Angus	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error
8- 7-47	11.6	11.1	11.3	9	1.01	.34	9	1.15	.38	10	1.25	.40
9- 4-47	10.9	9.9	10.3	10	1.01	.32	10	.93	.29	10	1.11	.35
10- 1-47	8.6	9.8	8.7	8	1.73	.61	8	.61	.22	7	.54	.20
10-30-47	9.5	9.8	9.1	9	1.04	.35	8	.95	.34	9	.87	.29
12- 8-47	9.4	9.4	9.6	9	.76	.25	8	1.24	.44	9	1.27	.43
1- 7-48	8.8	9.4	9.5	8	1.15	.41	10	1.53	.48	10	.87	.28
2-24-48	8.2	8.5	8.1	10	.95	.30	10	1.24	.39	9	.89	.30
3-26-48	9.0	9.1	8.9	10	.89	.28	9	1.35	.45	9	.87	.29
4-26-48	8.9	8.9	8.6	8	.57	.20	9	.66	.22	8	.98	.35
6- 1-48	10.0	10.5	10.1	10	.91	.29	9	.53	.18	10	.74	.23
7- 1-48	10.2	9.6	10.1	10	1.07	.34	10	1.35	.43	8	.87	.31
9- 2-48	13.1	13.2	12.9	10	1.36	.43	10	1.09	.34	9	1.23	.41
11- 2-48	12.4	12.2	11.9	10	.77	.24	10	1.11	.35	10	1.32	.42
12-14-48	9.9	9.3	10.6	10	2.20	.70	10	1.37	.43	10	2.28	.72
1-13-49	11.1	12.0	11.7	10	.86	.27	10	1.46	.46	10	1.50	.48
2-22-49	11.3	12.2	12.1	10	.72	.23	10	.95	.30	9	1.09	.36
3-22-49	9.9	12.1	11.5	10	.69	.22	9	1.02	.34	10	1.07	.34
4-27-49	12.9	12.5	13.1	10	.59	.19	9	1.17	.39	10	1.18	.37
5-31-49	12.2	12.5	12.5	10	1.04	.33	10	.89	.28	10	.90	.29
6-27-49	11.7	11.8	11.9	10	1.64	.52	10	.76	.24	10	1.61	.51

ERYTHROCYTE COUNT

Table VII.—Erythrocyte Count of Beef Cattle Blood.

(Millions per cubic millimeter)

Date of Sampling	Average Composition of Plasma			Variance								
				Hereford			Shorthorn			Angus		
	Hereford	Shorthorn	Angus	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error	No.	Standard Deviation	Standard Error
8- 7-47	6.58	6.25	6.36	9	.65	.22	9	.86	.29	10	.85	.27
9- 4-47	5.79	5.38	5.71	10	.47	.15	10	.54	.17	10	.67	.21
10- 1-47	4.62	5.33	4.74	8	.94	.33	8	.45	.16	7	.65	.25
10-30-47	5.18	5.58	5.01	9	.56	.19	8	.55	.19	9	.33	.11
12- 8-47	4.86	5.07	5.03	9	.41	.14	8	.58	.20	9	.55	.18
1- 7-48	4.66	5.19	4.85	8	.36	.13	10	.83	.26	10	.42	.13
2-24-48	4.33	4.41	4.14	10	.42	.13	10	.74	.23	9	.44	.15
3-26-48	4.90	4.92	5.00	10	.48	.15	9	.89	.30	9	.67	.22
4-26-48	4.60	4.39	3.71	8	.24	.08	9	.43	.14	8	.46	.16
6- 1-48	5.65	5.88	5.66	10	.56	.18	9	.36	.12	10	.61	.19
7- 1-48	6.17	6.26	5.53	10	.56	.18	10	.37	.12	8	1.69	.60
9- 2-48	5.45	6.06	5.73	10	.62	.20	10	.48	.15	9	.56	.19
11- 2-48	5.92	6.14	6.03	10	.44	.14	10	.56	.18	10	.80	.25
12-14-48	5.64	5.73	6.11	10	.36	.11	10	.51	.16	10	.86	.27
1-13-49	5.51	5.79	5.95	10	.41	.13	10	.47	.15	10	.79	.25
2-22-49	5.04	5.45	5.14	10	.36	.11	10	.41	.13	9	.65	.22
3-22-49	5.32	5.38	5.48	10	.40	.13	9	.46	.15	10	.68	.21
4-27-49	5.29	5.45	5.33	10	.27	.09	9	.47	.16	10	.74	.24
5-31-49	5.01	5.26	5.29	10	.47	.15	10	.37	.12	10	.51	.16
6-27-49	5.33	5.30	5.04	10	.61	.19	10	.36	.11	10	.70	.22